CLAIMS

What is claimed is:

1. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:

a. an electrolyte secured between an anode catalyst and a cathode catalyst;

b. a porous anode substrate secured in direct fluid communication with the anode catalyst for passing the reducing fluid stream adjacent the anode catalyst and a wetproofed cathode support means secured in direct fluid communication with the cathode catalyst for passing the process oxidant stream adjacent the cathode catalyst;

c. a porous water transport plate secured in direct fluid communication with the wetproofed cathode support means; and,

d. a direct antifreeze solution passing through the porous water transport plate for cooling the fuel cell, wherein the direct antifreeze solution is an organic antifreeze solution that does not wet the wetproofed cathode support means and that is non-volatile at cell operating temperatures.

2. The direct antifreeze cooled fuel cell of Claim 1, wherein the antifreeze solution is an alkanetriol direct antifreeze solution.

3. The direct antifreeze cooled fuel cell of Claim 1, wherein the antifreeze solution is an alkanetriol direct antifreeze solution selected from the group consisting of glycerol, butanetriol, and pentanetriol.

4. The direct antifreeze cooled fuel cell of Claim 1, wherein the fuel cell includes a pressure control means for maintaining a positive pressure differential between the process oxidant stream passing through the fuel cell and the antifreeze solution passing through the porous water transport plate so that the process oxidant stream within the fuel cell is at a greater pressure than the antifreeze solution within the water transport plate.

5. The direct antifreeze cooled fuel cell of Claim 1, wherein the process oxidant stream enters an oxidant inlet of the fuel cell at greater than approximately 30% relative humidity at a temperature at the oxidant inlet.

6. The direct antifreeze cooled fuel cell of Claim 1, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a wetproofed cathode substrate and the cathode catalyst.

7. The direct antifreeze cooled fuel cell of Claim 1, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a cathode substrate and the cathode catalyst.

8. The direct antifreeze cooled fuel cell of Claim 1, wherein the electrolyte is a proton exchange membrane.

9. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:

a. an electrolyte secured between an anode catalyst and a cathode catalyst;

b. a wetproofed anode support means secured in direct fluid communication with the anode catalyst for passing the reducing fluid stream

adjacent the anode catalyst and a wetproofed cathode support means secured in direct fluid communication with the cathode catalyst for passing the process oxidant stream adjacent the cathode catalyst;

c. a porous anode water transport plate secured in direct fluid communication with the wetproofed anode substrate means, and a porous cathode water transport plate secured in direct fluid communication with the wetproofed cathode support means; and,

d. a direct antifreeze solution passing through the porous anode and cathode water transport plates for cooling the fuel cell, wherein the antifreeze solution is a special direct antifreeze solution having;

i. a freezing point of at least $-20^{0}F$;

ii. a surface tension greater than 60 dyne/cm at an operating temperature of the fuel cell;

iii. a partial pressure of antifreeze above the solution at the cell operating temperature that is less than 0.005 mm Hg; and,

iv. a capacity of being oxidized by the anode and cathode catalysts at fuel cell voltages.

10. The direct antifreeze cooled fuel cell of Claim 9, wherein the antifreeze solution is an alkanetriol direct antifreeze solution.

11. The direct antifreeze cooled fuel cell of Claim 9, wherein the antifreeze solution is an alkanetriol direct antifreeze solution selected from the group consisting of

glycerol, butanetriol, and pentanetriol.

12. The direct antifreeze cooled fuel cell of Claim 9, wherein the fuel cell includes a pressure control means for maintaining a positive pressure differential between the process oxidant stream passing through the fuel cell and the antifreeze solution passing through the porous anode and cathode water transport plates so that the process oxidant stream within the fuel cell is at a greater pressure than the antifreeze solution within the water transport plates.

13. The direct antifreeze cooled fuel cell of Claim 9, wherein the process oxidant stream enters an oxidant inlet of the fuel cell at greater than approximately 30% relative humidity at a temperature of the oxidant inlet.

14. The direct antifreeze cooled fuel cell of Claim 9, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a cathode substrate and the cathode catalyst, and the wetproofed anode support means includes a wetproofed anode diffusion layer secured between an anode substrate and the anode catalyst.

15. The direct antifreeze cooled fuel cell of Claim 9, wherein the electrolyte is a proton exchange membrane.

16. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:

a. a proton exchange membrane electrolyte secured between an anode catalyst and a cathode catalyst;

b. a wetproofed anode support means secured in direct fluid communication with the anode

catalyst for passing the reducing fluid stream adjacent the anode catalyst and a wetproofed cathode support means secured in direct fluid communication with the cathode catalyst for passing the process oxidant stream adjacent the cathode catalyst;

c. a porous anode water transport plate secured in direct fluid communication with the wetproofed anode support means, and a porous cathode water transport plate secured in direct fluid communication with the wetproofed cathode support means; and,

d. an alkanetriol direct antifreeze solution passing through the porous anode and cathode water transport plates for cooling the fuel cell.

17. The direct antifreeze cooled fuel cell of Claim 16, wherein the fuel cell includes a pressure control means for maintaining a positive pressure differential between the process oxidant stream passing through the fuel cell and the antifreeze solution passing through the porous anode and cathode water transport plates so that the process oxidant stream within the fuel cell is at a greater pressure than the antifreeze solution within the water transport plates.

18. The direct antifreeze cooled fuel cell of Claim 17, wherein the process oxidant stream enters an oxidant inlet of the fuel cell at greater than approximately 30% relative humidity at a temperature at the oxidant inlet.

19. The direct antifreeze cooled fuel cell of Claim 18, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a cathode substrate and the cathode catalyst, and the

wetproofed anode support means includes a wetproofed anode diffusion layer secured between an anode substrate and the anode catalyst.

20. The direct antifreeze cooled fuel cell of Claim 19, wherein the direct antifreeze solution defines an antifreeze solution coolant stream flow pattern through the fuel cell that is transverse-concurrent to an oxidant flow axis defined by the process oxidant stream passing through the fuel cell, and wherein the reducing fluid stream defines a reducing fluid flow pattern through the fuel cell that is transverse-concurrent to the oxidant flow axis.